

Barium was analyzed in 393 samples for this study and was found in 388, or 98.7% (Table 10). Plotted against physiographic provinces and land use, the majority of barium values occur within narrow ranges (Figures 24 and 25). The widest range of values occurs in the Eastern Coal Field and in forested areas. Four sites in the Eastern Coal Field (Figure 26) had the highest detections of barium, including the Rousseau well in Breathitt County, with values approaching 3.0 mg/L, and the Whiskey Store well in Perry County, which measured from about 1-2 mg/L. The Baker and Homeplace wells were also high in barium, as was the Glenwood Hall well in Owen County.

Barium distribution in BMU 1 is most likely naturally occurring and no nonpoint sources were noted that could explain the high results in the wells discussed above.

Iron (Fe) is commonly found in trace amounts (or more) in practically all sediments and sedimentary rocks (Driscoll, 1986). Iron is one of the most common groundwater quality problems encountered in wells in Kentucky. However, in almost all cases, elevated iron is naturally occurring and therefore not generally diagnostic of nonpoint source pollution. One notable exception is that high levels of iron are often associated with run-off from coal mining. Typically, this high iron discharge affects surface water rather than groundwater, but wells penetrating old mine works, or those under the direct influence of surface water, can also be affected.

Iron is a common element found in most groundwater and affects the suitability of water for drinking and industrial use. Iron helps transport oxygen in the blood and is essential for good health. Excessive iron in water used for human consumption is an aesthetic, rather than a health-based, concern. Iron has an SMCL of 0.3 mg/L. For most people, amounts greater than this cause objectionable taste and odor.

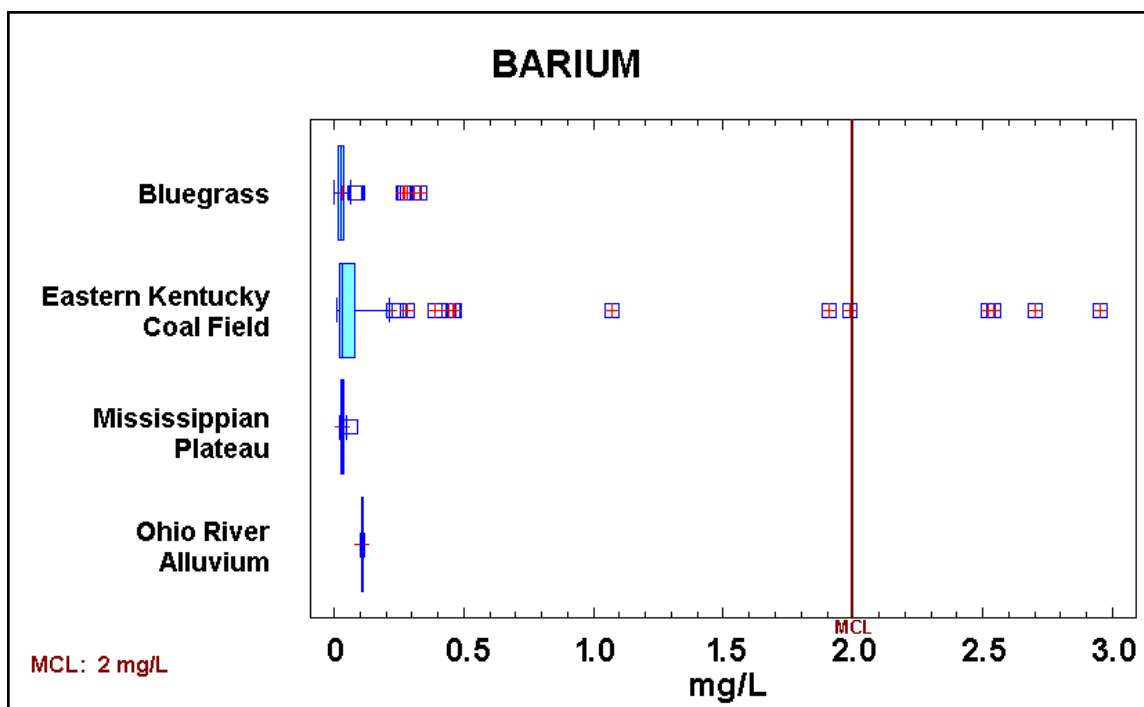


Figure 24. Boxplot of Barium and Physiographic Regions

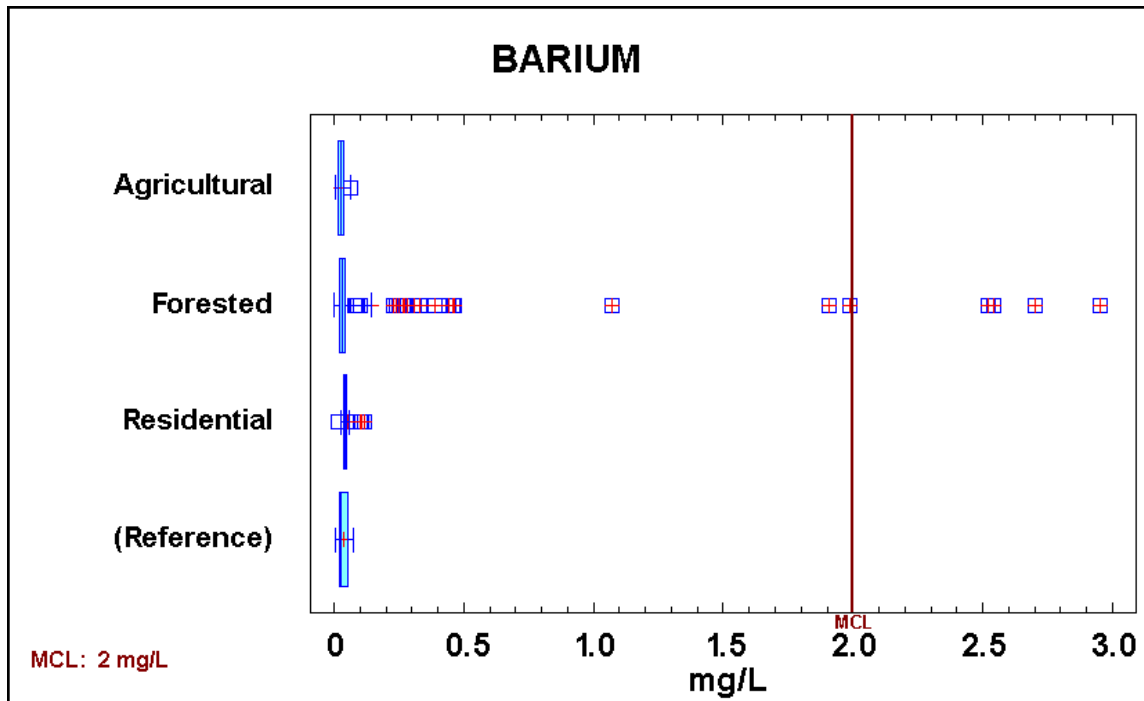


Figure 25. Boxplot of Barium and Land Use

# BMU 1 Median Barium Data

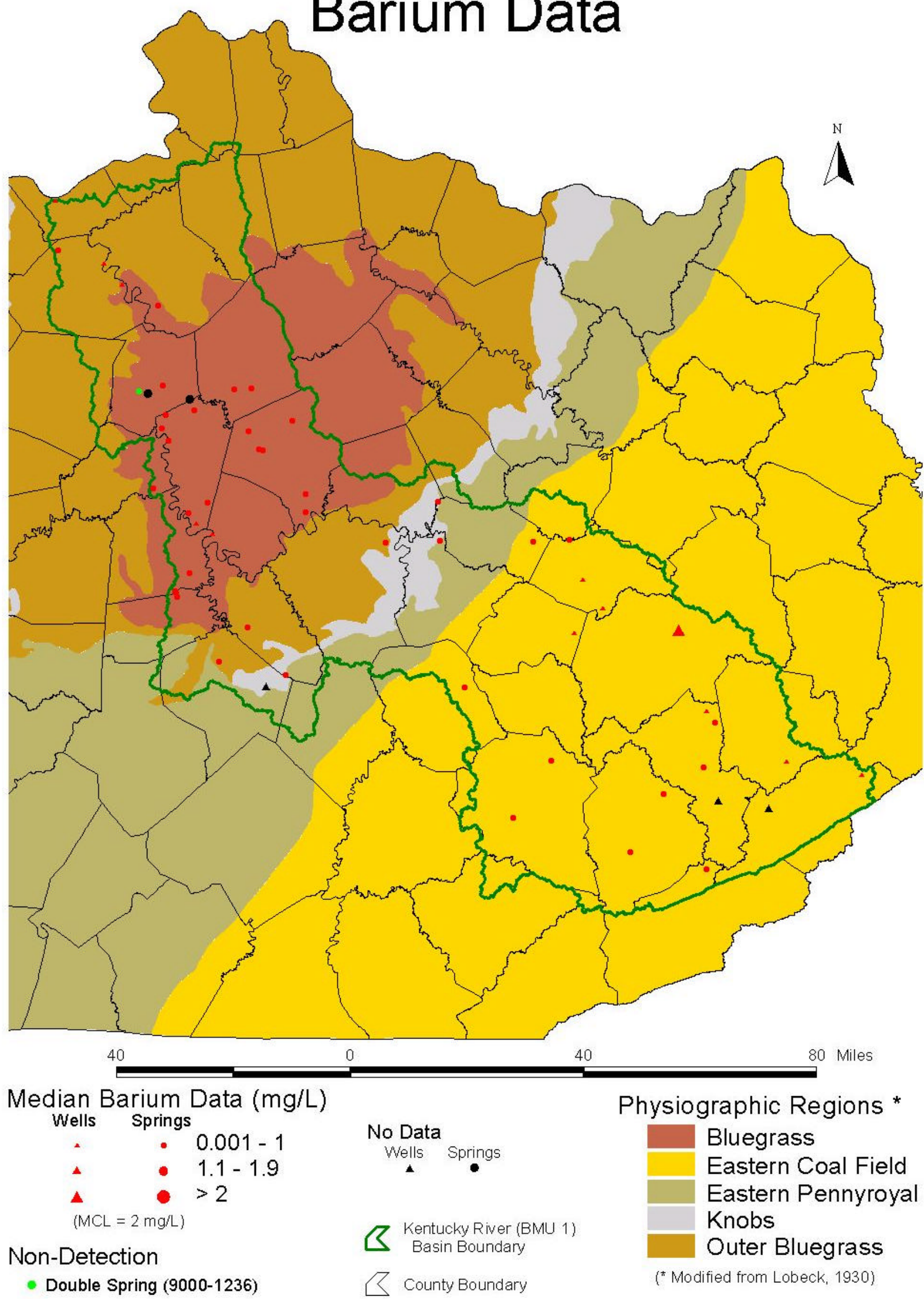


Figure 26. Barium Map

Iron causes problems when it changes from the dissolved, or *ferrous*, state to the precipitated state, or as *ferric* iron. Precipitated iron can coat or encrust well screens and casing, pipes, pumping equipment and plumbing fixtures. Additionally, various metal-reducing bacteria, or “iron bacteria”, that feed on iron can coat fixtures. These bacteria can grow to such an extent that a gelatinous mass is formed that can completely plug a well and associated equipment. Although iron bacteria are not usually a health problem, they render the water unpalatable and are indicators of unsanitary conditions that may harbor other, more harmful, bacteria.

Iron (Table 10) was measured in 393 samples and detected in 379 (96.4%). Median values (Table 11) ranged from a low of 0.056 mg/L in the Mississippian Plateau to a high of 0.663 mg/L in the Ohio River Alluvium. The Eastern Coal Field, which is well known for the high content of iron in wells, and the Bluegrass had surprisingly similar median values of 0.127 mg/L and 0.1205 mg/L respectively. Figures 27 and 28 plot the distribution of iron against physiographic provinces and land use. Median values are low, but there is a great amount of variability, especially in the Bluegrass and the Eastern Coal Field, and in agricultural and forested areas. Map distribution is shown in Figure 29. The highest iron values were found in the Rousseau and Baker wells in the Eastern Coal Field. Glenwood Hall had the highest iron content in the Bluegrass; however, as noted above, this well is completed in alluvium and does not produce from the carbonate bedrock typical of the Bluegrass.

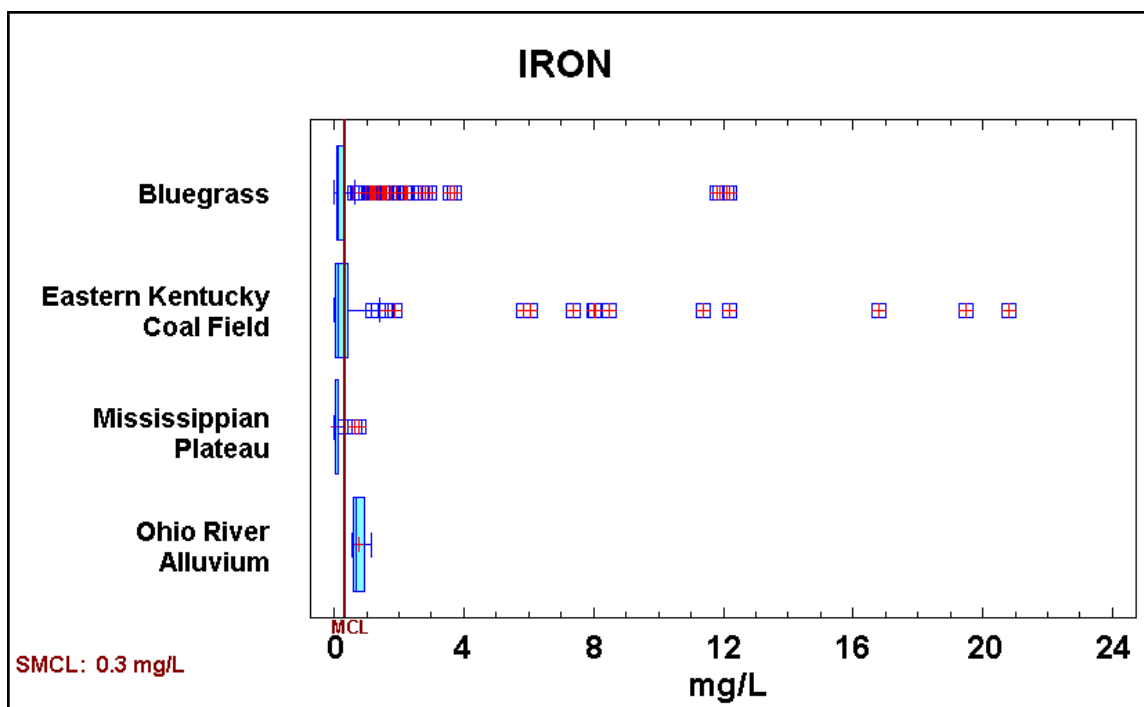


Figure 27. Boxplot of Iron and Physiographic Regions

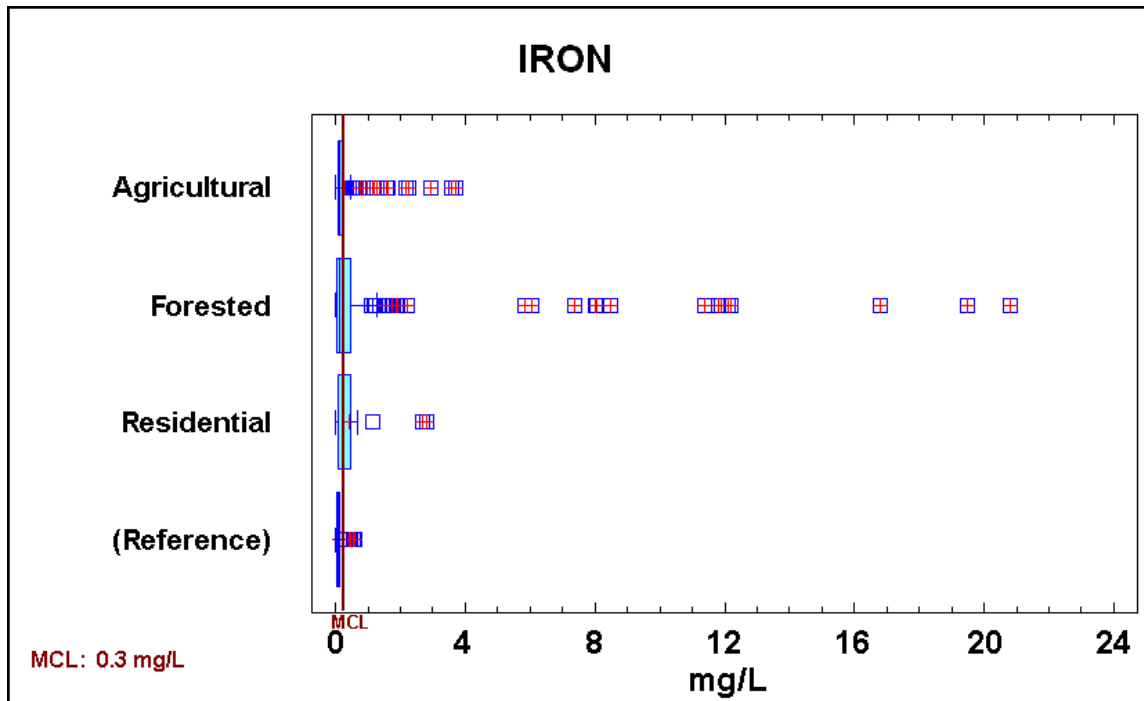


Figure 28. Boxplot of Iron and Land Use



# BMU 1 Median Iron Data

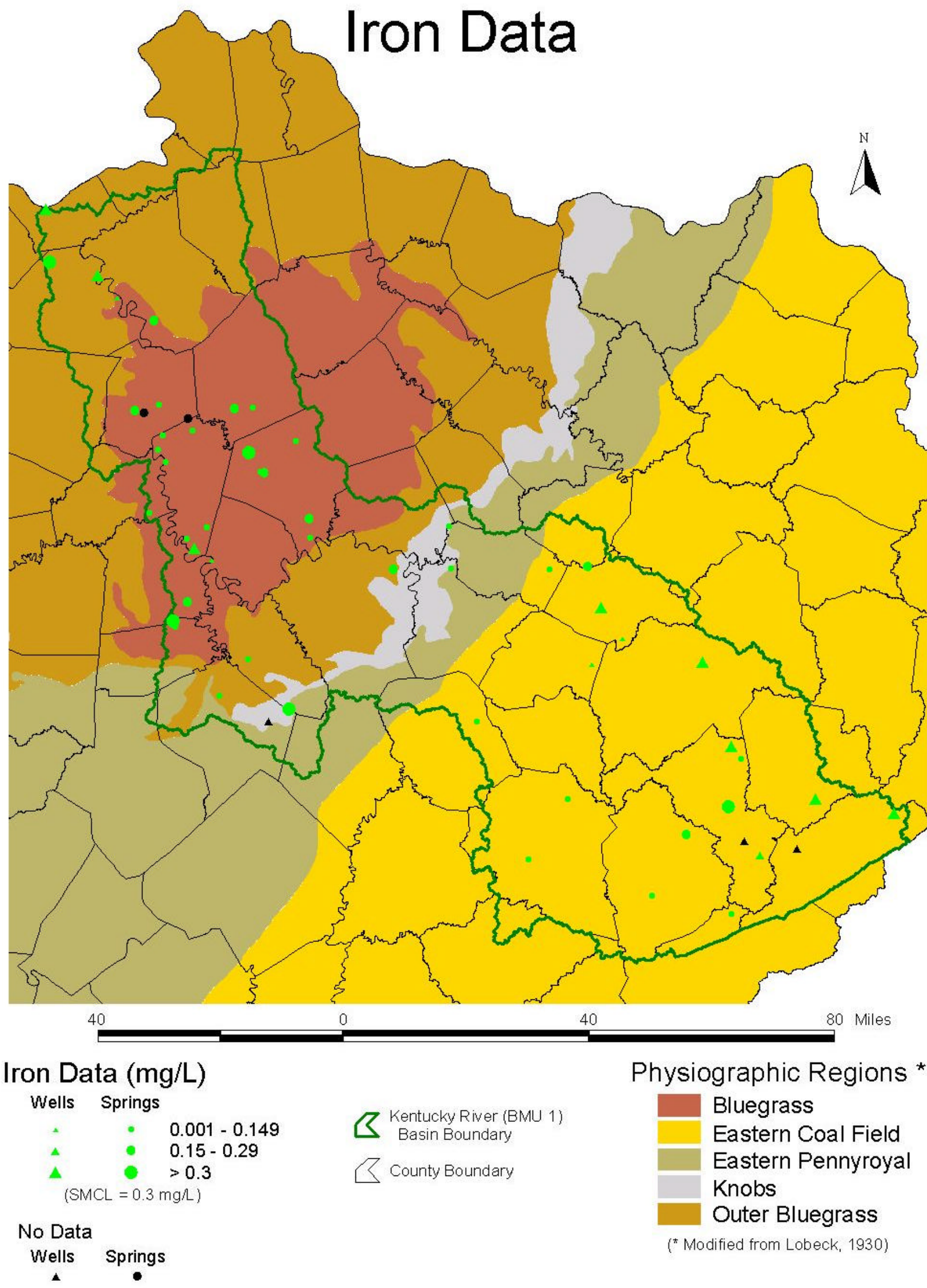


Figure 29. Iron Map

In summary, based upon the well-documented occurrence of iron in Kentucky's groundwater and the lack of any apparent nonpoint sources, iron in BMU 1 groundwater results from natural sources and is not a nonpoint source pollutant.

Manganese (Mn) is a relatively common element, but it occurs less abundantly in groundwater than does iron. Manganese is associated with discharges from coal mining and metal manufacturing. Manganese in water supplies can cause staining and encrustation of plumbing fixtures, piping and well screens, as well as discolored laundry. The SMCL for manganese is 0.05 mg/L. Manganese is a common, naturally occurring, water quality problem in Kentucky.

Manganese was detected in 355 of 393 (90.3%) of the samples included in this study and twenty-four sites had at least one detection above SMCL (Tables 10 and 11). Median values ranged from a low of 0.003 mg/L in the Mississippian Plateau to a high of 0.133 mg/L in the Ohio River Alluvium, but the highest value of 1.38 was found in the Eastern Coal Field at Aunt Soph's Spring in Clay County (Table 11). Boxplots (Figures 30 and 31) show the variability of manganese in two physiographic provinces, the Bluegrass and the Eastern Coal Field, and especially in agricultural and forested areas. Map distribution is shown in Figure 32.

Without direct evidence of any apparent nonpoint sources of this common metal, the manganese results found in this study are interpreted as the result of naturally occurring variations in water chemistry.

Mercury (Hg) occurs naturally in the Eastern Coal Field as a trace element in coal (USGS, 2002b). Primary nonpoint sources of mercury pollution are via atmospheric deposition from coal-burning power plants and boilers, waste incineration and manufacturing. Berryman and others (2004) note in their study of Mammoth Cave National Park that mercury levels in surface and groundwater are “. . . quite low (0-25 ppt) since mercury preferentially binds to sediments and organic material.” Some mercury is converted to organic mercury (primarily methylmercury) in the environment and accumulates in fish. Because mercury can then

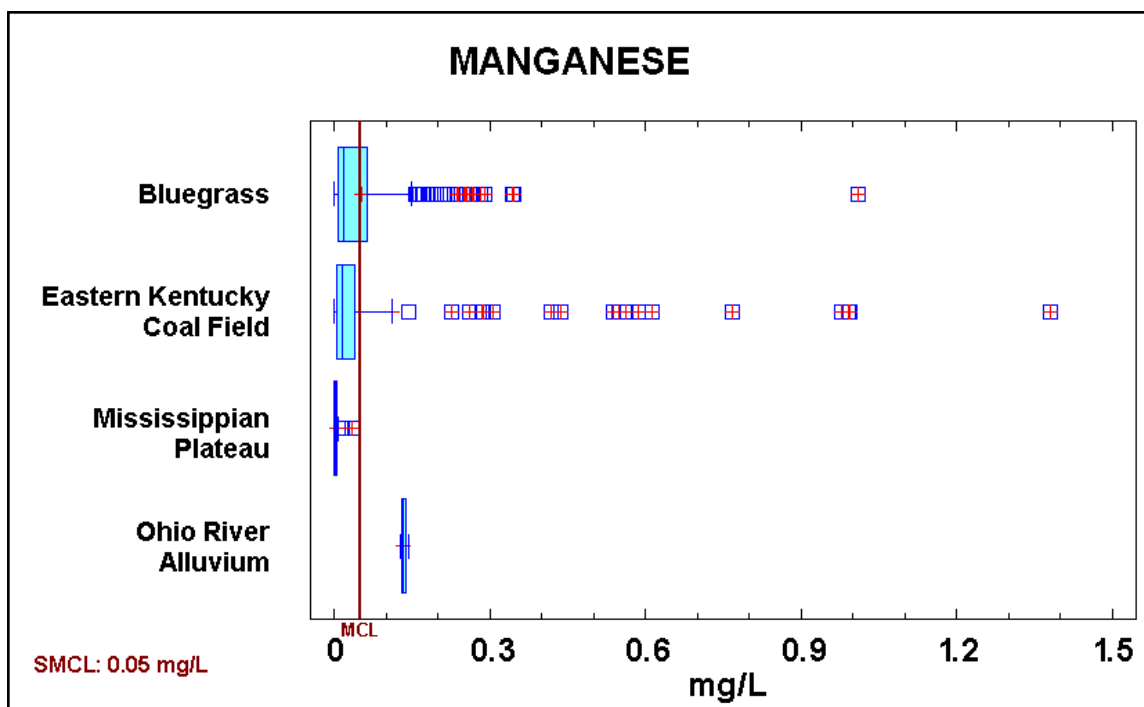


Figure 30. Boxplot of Manganese and Physiographic Regions

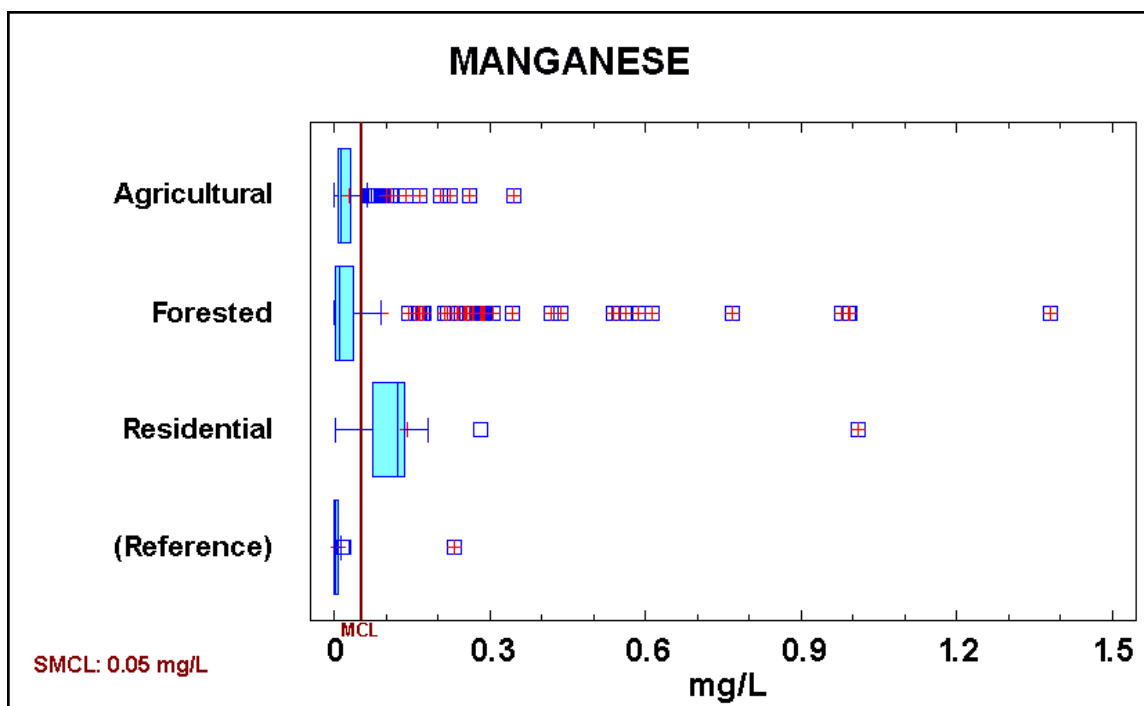


Figure 31. Boxplot of Manganese and Land Use



# BMU 1 Median Manganese Data

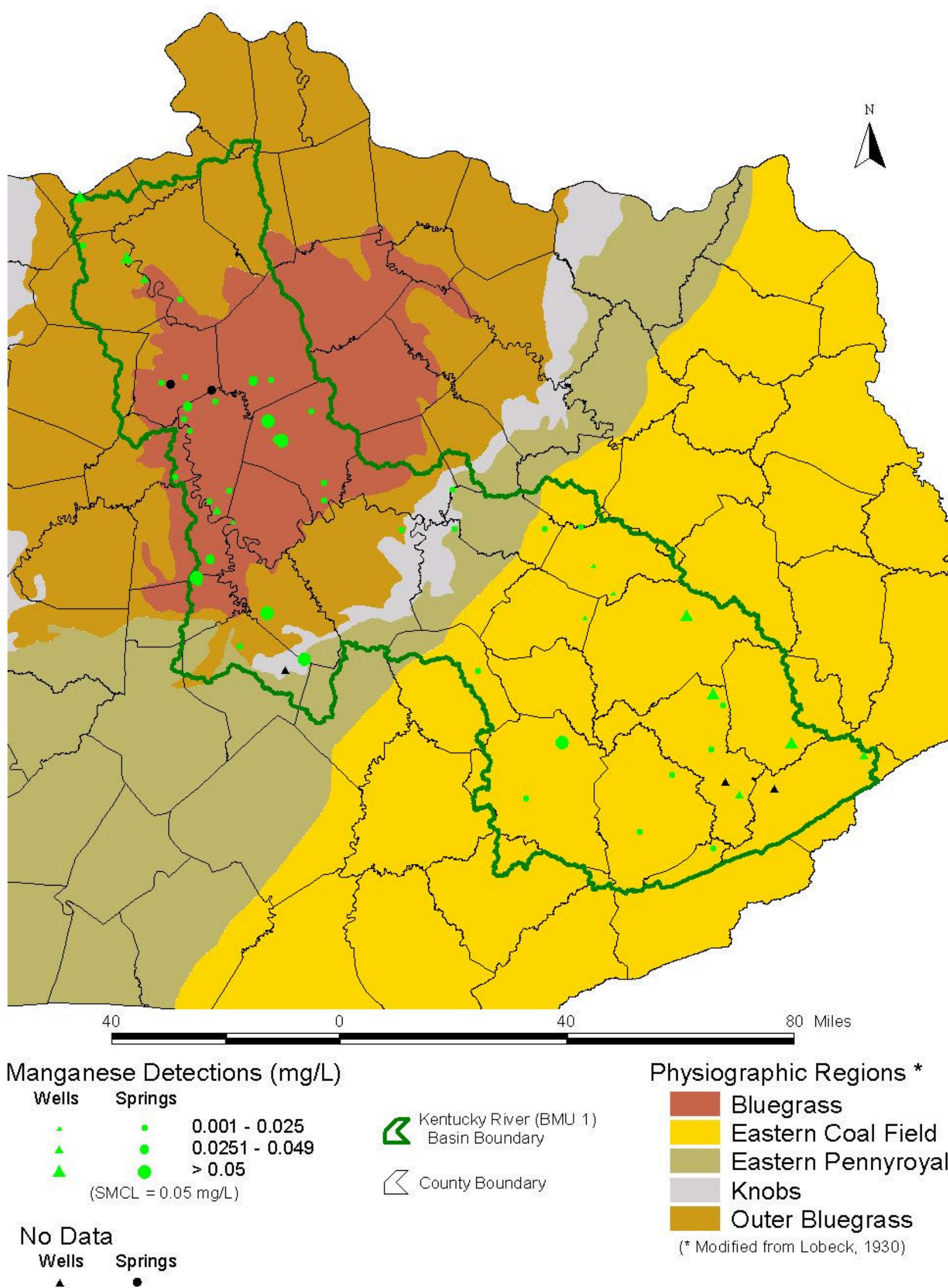


Figure 32. Manganese Map

accumulate in humans with serious effects upon the nervous system, the US EPA (2004) has issued consumer advisories to limit consumption. The MCL for mercury is 0.002 mg/L.

Mercury occurred in 1 of 392 samples, or 0.3% (Table 10). The single detection, 0.000065 mg/L, was in one of 28 samples collected at Russell Cave Spring (Fayette County) in the Inner Bluegrass Physiographic province (Table 11). No source of this anomalous detection of mercury was found.

Mercury data strongly suggest that this metal does not occur naturally in groundwater in the study area, nor does it apparently impact groundwater through air-borne deposition from coal-fired power plants or other sources. Although the Division of Water has issued statewide fish consumption advisories for mercury, groundwater in BMU 1 does not appear to contribute to this surface water problem. However, because mercury does occur as a trace element in coal and because air-borne deposition from coal-fired power plants is on going, additional sampling should include mercury to monitor potential long-term impacts to groundwater.

Lead (Pb) occurs naturally as the mineral galena (PbS), which is found as a vein mineral in central Kentucky (Anderson and Dever, 1998). Lead also occurs in carbonate sedimentary rocks (Dever, 2000) and is found as a trace element in coal (USGS, 2002b). Atmospheric deposition through coal-fired power plants, as well as the historical use of “leaded” gasoline has dispersed lead throughout the environment. Industrial uses of lead include historical use as an additive in paint, but current use is dominated by lead batteries, which accounts for about 88% of current use, with the remaining 12% used in a variety of products, including ceramics and ammunition (USGS, 2004). Lead toxicity is well documented (US EPA, 2002c), and in children can severely affect growth and intellectual development. Lead (along with copper) is regulated by “Treatment Technique” which requires public water systems to control the corrosiveness of their water. The action level for lead is 0.015 mg/L, and if more than 10% of tap water samples exceed this, then water systems are required to take additional steps.

Lead was detected in 41 of 395 (10.4%) samples analyzed in this study (Table 10). The median for BMU 1 was less than 0.002 mg/L (Table 11), but two springs in the Bluegrass and one well in the Ohio River Alluvium had detections exceeding the action level: Russell Cave Spring (Fayette County), Royal Spring (Scott County), and a well in Carrollton (Carroll County). These sites occur in locales with numerous potential sources of contamination, and the provenance of lead occurrence at these sites is unknown. Median values are low in all physiographic provinces (Figure 33), but elevated outliers are common in the Bluegrass and Eastern Coal Field. The boxplot of lead and land use (Figure 34) shows most values are low, but with variability in all areas. Distribution of lead in BMU 1 is shown in Figure 35.

The provenance of lead in groundwater in BMU 1 is difficult to interpret, but may be, at least in part, the result of nonpoint source pollution, possibly through current and historical atmospheric re-deposition from coal and gasoline. Because of its detrimental impacts, lead should continue to be monitoring and additional studies developed to more fully characterize potential impacts to groundwater.

### **Pesticides (Atrazine, Metolachlor, Simazine, Alachlor and Cyanazine)**

Five commonly used pesticides are included in this report: atrazine (and one of its degradation by-products, atrazine desethyl), metolachlor, cyanazine, simazine and alachlor. A summary and descriptive statistics are shown in Tables 12 and 13.

Because these pesticides do not occur naturally and because their introduction into the environment from point sources such as leaking tanks is relatively limited geographically, the detection of pesticides in groundwater indicates nonpoint source pollution.

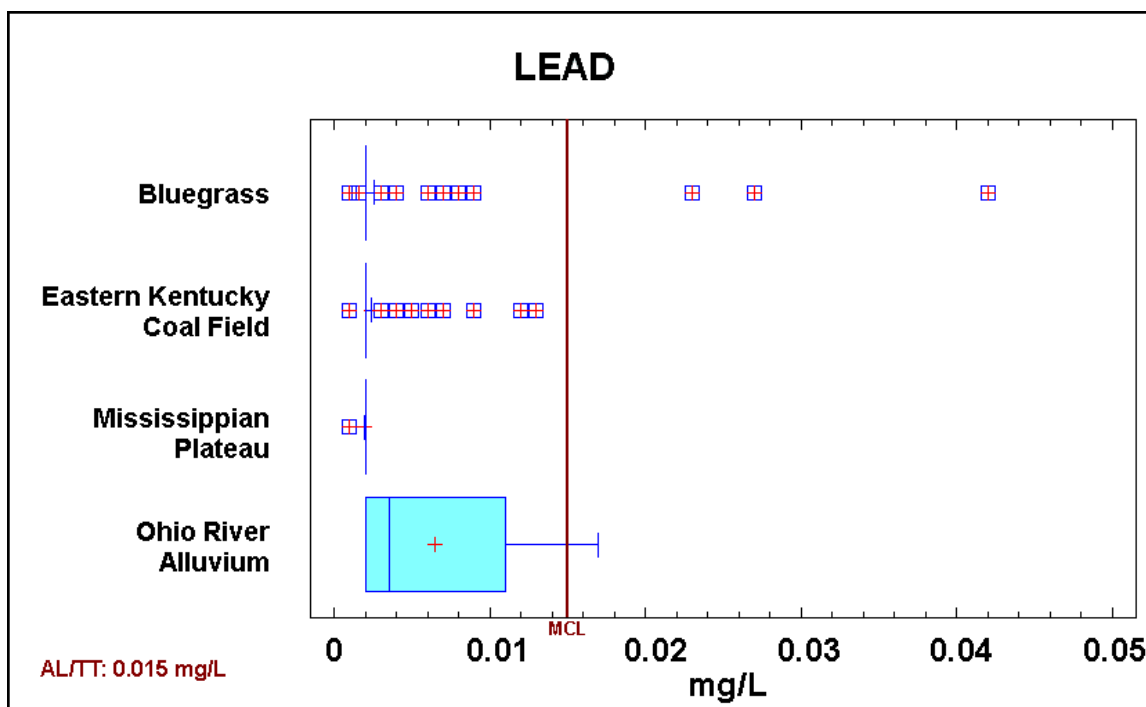


Figure 33. Boxplot of Lead and Physiographic Regions

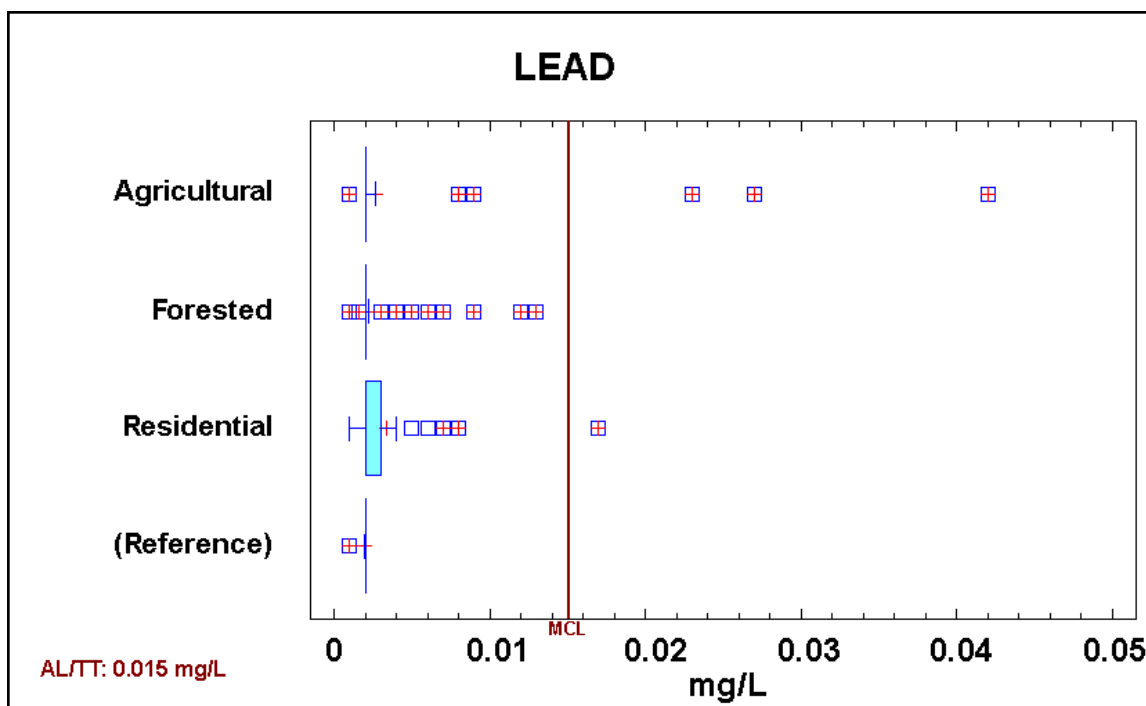


Figure 34. Boxplot of Lead and Land Use



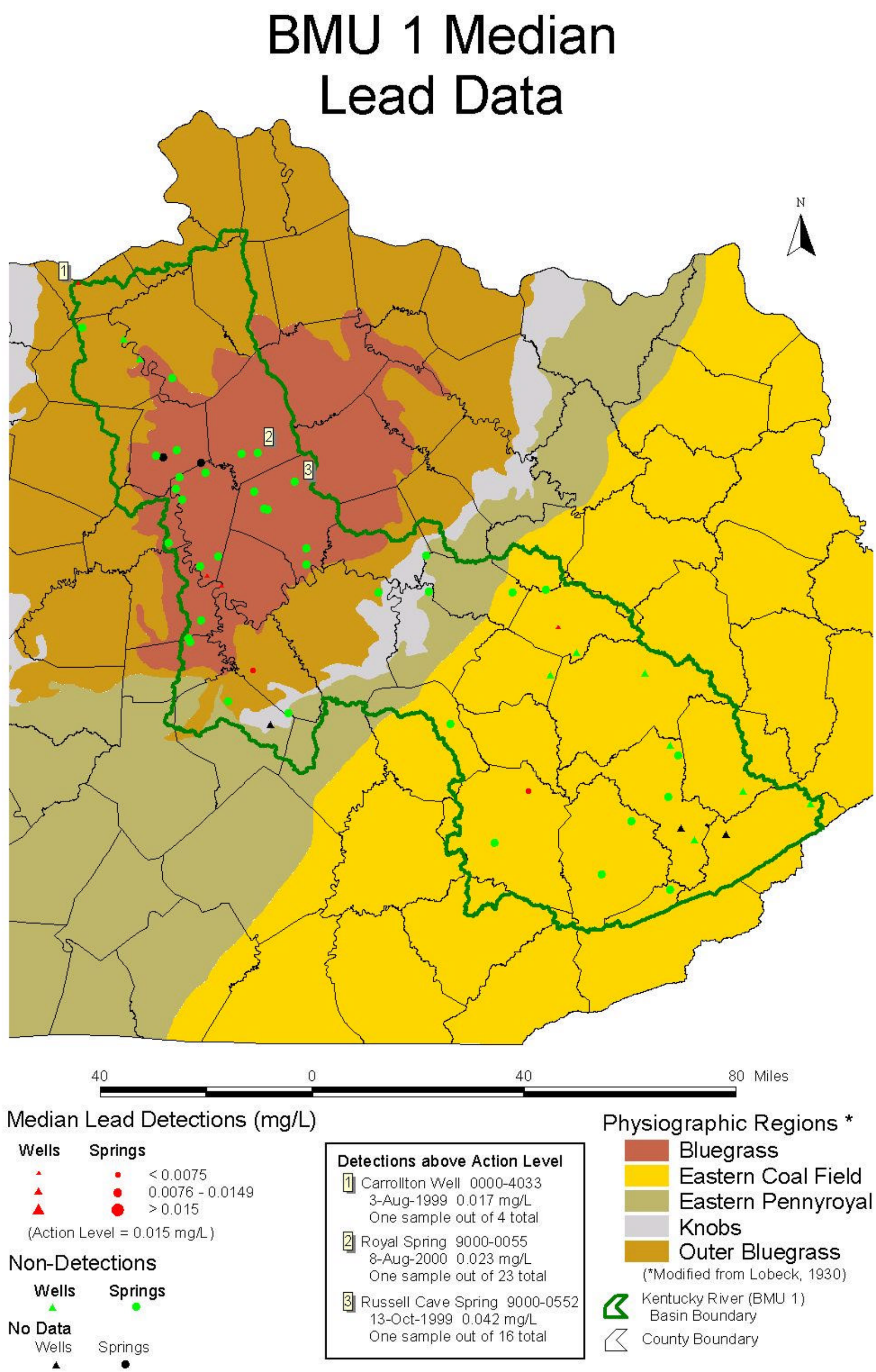


Figure 35. Lead Map